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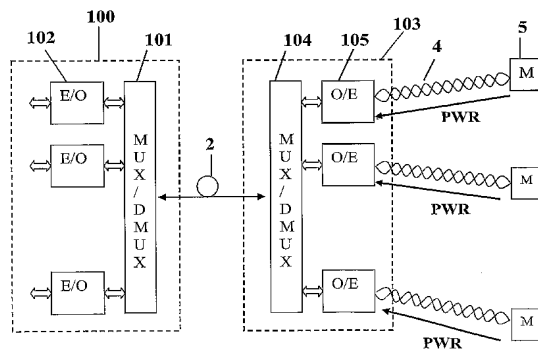
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(54) Title: METHOD FOR ESTABLISHING A SUBSCRIBER CONNECTION AND A SYSTEM UTILIZING THE METHOD



(57) Abstract: The objective of the invention is to devise a method for establishing a subscriber connection and a system applying the method. According to the method, a digital subscriber connection consisting of a composition of an optical fiber and a metallic pair cable is implemented by transporting a digital information stream in two directions over an optical fiber (2) between a central site and equipment (103) which is connected to the metallic pair cable (4) of each subscriber. According to the invention, the information streams transmitted and received over the pair cables are multiplexed onto the optical fiber by using a multiplexing method of optical signals, whereby the information streams originating from different subscribers are combined onto the fiber by means of passive optical elements and whereby the information streams transmitted from the central site are distributed to each subscriber-specific optical-to-electric conversion element (105) by means of passive optical elements. Thus the multiplexing and demultiplexing need no active multiplexing/demultiplexing electronics common to all subscribers, but rather the active electronics of the conversion elements (105) of each subscriber operates independently without being dependent on the state of operation of other subscriber's conversion elements. Hence the operating power for said electronics can be fed from the respective subscriber through the subscriber's pair cable.



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Method for Establishing a Subscriber Connection and a System Utilizing the Method

The invention relates to a method according to the preamble of claim 1 and a system
5 according to claim 3.

Accordingly, the invention consists of a method of establishing a digital FTTC (Fiber To The Curb, Fiber To The Cabinet) subscriber connection comprising an optical fiber and a metallic twisted pair cable. The invention also consists of converter
10 equipment connecting the fiber and the cable and an arrangement for supplying the operating power for the equipment, said converter equipment being an integral element of the subscriber connection.

Background of the invention

15 In a conventional subscriber network based on a twisted metallic pair cable, each subscriber is connected to a local telephone exchange or concentrator via said subscriber's own cable pair. A typical length of cable may be several kilometers. If the pair cable is utilized for transmitting digital information by means of DSL
20 (Digital Subscriber Line) modem techniques, the transfer characteristics of the cable limit the highest achievable transmission rate from a few hundred kilobits per second to a few megabits per second, depending primarily on the cable length.

Subsequently the term "central site" represents the local telephone exchange or
25 concentrator site.

Subsequently a DSL modem stands for, in a broader sense, a transmission device, which converts a digital information stream into an analog signal that can be transmitted over a metallic pair cable by utilizing a usable frequency band and which
30 detects a received signal and converts it reliably into the original digital information stream. A metallic pair cable is a very difficult transmission media incurring strong linear amplitude and phase distortion among other impairments. These impairments are typically equalized by using tools offered by digital signal processing, e.g.

adaptive line equalization. Several different modulation methods can be used, e.g. DMT modulation (Discrete MultiTone) or QAM (Quadrature Amplitude Modulation). The modulation method utilized and the detailed implementation of the signal processing, for example, are not essential for the operation of the method and system according to the invention.

When utilizing a conventional subscriber network for digital transmission, the signal conversion in the interface of the subscriber cable and the trunk network is typically carried out by DSLAM equipment (Digital Subscriber Line Access Multiplexer). A DSLAM comprises DSL modems, which transform the digital signal into an analog form suitable for transmission over the metallic cable. The DSL modems also receive the signal coming from the far end subscriber transmitter and convert the signal into digital form. Furthermore, the DSLAM multiplexes traffic from several subscribers and transmits the traffic to the trunk network.

In a digital FTTC subscriber network, data streams for several subscribers are multiplexed to an optical fiber and transported nearer to the subscribers over the fiber so that the lengths of the metallic pair cables are substantially shorter as compared to a conventional subscriber network. As a consequence, the digital transmission speed can be increased considerably, because the shorter the cable is, the higher the usable bandwidth. A new problem arises in an FTTC network from the fact that now the DSLAM is placed nearer to the subscribers and away from the central site. The DSLAM of a conventional network is installed at the central site, where it is much easier to arrange the necessary power supply and where the environmental factors (temperature and humidity) crucial for the equipment electronics are easier to control. In an FTTC network topology, the remote DSLAM (subsequently RDSLAM) has to be installed, for example, in a box located at a street corner, where the power supply arrangement is laborious and where the electronics suffer from wide temperature and humidity variations. A substantial portion of the electronics of DSLAM equipment is located in the digital transceivers of the DSL modems and in the circuitry multiplexing the data stream onto the optical fiber. Also, a substantial amount of power consumption is used for supplying said electronics. FIG. 1 represents FTTC network topology based on known technology. An optical fiber

connects RDSLAM equipment 3 to equipment 1 at the central site, where the fiber is connected to a switching device of the trunk network, e.g. an ATM switch or an IP router, depending on the transport protocol.

5 The method of reference [1] succeeds in overcoming some of the problems described above. According to the method of reference, the analog interface of the DSL modems at the central site DSLAM is connected to the system so that the central site equipment converts the modem analog signal into a digital sample sequence. The sample sequence is transmitted through an optical fiber to the far end and converted
10 back into an analog signal, which is then fed into a twisted pair subscriber cable. The same procedure is carried out as well in the reverse transmission direction, from the subscriber towards the central site. Hence the system is entirely symmetrical, and identical equipment is needed at both ends of the optical fiber. Thus the interface between the system and the central site DSL modems connects analog signals in both
15 transmission directions. In another method of reference [1], the modem signals are multiplexed as analog signals by using analog modulation and demodulation.

Reference [2] introduces a method whereby the equipment at the subscriber end of the optical fiber can be implemented with simple active electronics comprising only
20 the analog parts of the DSL modems and a multiplexer element adapting the analog-to-digital and digital-to-analog converters of the analog parts to the optical fiber.

In the methods of the above-cited references [1 and 2] the electronics of RDSLAM equipment are considerably simpler compared to a conventional RDSLAM. In
25 systems according to the cited methods, likewise in a conventional FTTC system, there is still a problem in supplying the operating electric power. The operating power has to be fed to the equipment either from the central site via a power feeding cable or by connecting a power feeding cable from the main system for electricity distribution to the RDSLAM. The installation and maintenance cost is thus increased,
30 primarily because it is not always possible to draw power-feeding cables through the shielding tubes originally intended for optical fibers.

The objective of the present invention is to overcome the problems of prior-art technology and to provide an entirely novel method for establishing an FTTC subscriber network and arranging the operating power feeding for RDSLAM equipment.

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Summary of the invention

The objective of the invention is to forge a method which enables subscriber-specific conversion equipment which adapts an optical fiber to a pair cable and is located at
10 the end of the fiber near the subscribers to operate independently, without being dependent on the operation of the conversion equipment of other subscribers, making it possible to feed the operating electric power for the conversion equipment of each subscriber via the respective metallic pair cable from the subscriber end of the pair cable.

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The objective is achieved by the method according to the invention, characterized by what is stated in the characterizing part of claim 1, and by the system according to the invention, characterized by what is stated in the characterizing part of claim 3.

20 Subsequently the term "multiplexing of optical signals" stands for a multiplexing method whereby (i) subscriber-specific electric signals (information streams) originating from several subscribers are first converted into subscriber-specific optical signals and said optical signals are further combined and fed onto an optical fiber by means of passive optical elements and (ii) subscriber-specific optical signals
25 (information streams) produced at the central site, transmitted over the optical fiber and intended for each subscriber are first distributed to each subscriber-specific conversion element by means of passive optical elements and said conversion element separates the subscriber-specific signal from other subscribers' signals, converts the signal into an electric signal, and feeds the electric signal into the pair
30 cable of the respective subscriber.

In a preferred embodiment of the invention, the RDSLAM equipment contains all the essential electronics of the DSL modems, comprising a digital transmitter and

receiver and modem analog parts. The digital information stream specific for each subscriber is transported over the optical fiber in both directions by multiplexing optical signals.

- 5 In a second preferred embodiment of the invention, the RDSLAM equipment contains only the analog parts of the modems, whereas the digital transceivers are located at the central site. The digital sample sequences transferred between the subscriber-specific transceiver and the analog parts are transported over the optical fiber by utilizing a multiplexing method of optical signals.

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In a third preferred embodiment, the RDSLAM equipment contains only the analog parts, excluding the AD and DA converters (Analog-to-Digital and Digital-to-Analog converters). The optical fiber transports full-duplex analog signals, which are specific for each subscriber, between the AD and DA converters located at the central site and the analog parts located in the RDSLAM equipment. Said analog signals of each subscriber are separated from each other by multiplexing optical signals.

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The invention offers substantial advantages.

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In FTTC topology, the operating power for the electronics of the RDSLAM equipment installed in the hard environment at the subscriber end of the optical fiber can be fed through each subscriber cable from the subscriber end of the cable, thus eliminating the problems inherent in remote power feeding from the central site or from the main system for the distribution of electricity.

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In the following, the invention will be examined in greater detail with the help of exemplifying embodiments and the appended drawings.

30 *List of figures*

FIG. 1 represents the structure of a prior-art FTTC subscriber network and the RDSLAM equipment residing at the subscriber end of an optical fiber.

FIG. 2 depicts a principle of the invention whereby the electric signal that is transmitted over the metallic pair cable of each subscriber is converted into an optical signal, either in digital or analog form, and transported over the optical fiber by multiplexing the signals of each subscriber in optical form, and whereby the operating electric power for the electronics specific for each subscriber is fed from each subscriber's modem through the cable of each subscriber.

FIG. 3 illustrates a principle according to the invention whereby the subscriber-specific electronics located in the RDSLAM comprise the digital transceiver and the analog parts of a DSL modem.

FIG. 4 describes a principle of the invention whereby the subscriber-specific electronics located in the RDSLAM comprises only the analog parts of the DSL modems, including the AD and DA converters.

FIG. 5 depicts a principle of the invention whereby the subscriber-specific electronics located in the RDSLAM comprises only the analog parts of the DSL modems, excluding the AD and DA converters.

FIG. 6 illustrates central site equipment which is compatible with the RDSLAM of FIG. 3.

FIG. 7 represents central site equipment which is compatible with the RDSLAM of FIG. 4.

FIG. 8 illustrates central site equipment which is compatible with the RDSLAM depicted in FIG. 5.

Detailed description of the invention

The following abbreviations are used in this document:

	AD converter, ADC	Analog-to-Digital converter
	AGC	Automatic Gain Control
5	ATM	Asynchronous Transfer Mode
	DA converter, DAC	Digital-to-Analog Converter
	DMT modulation	Discrete MultiTone modulation
10	DSL	Digital Subscriber Line
	DSLAM	Digital Subscriber Line Access Multiplexer
15	FTTC	“Fiber To The Curb”, “Fiber To The Cabinet”, subscriber network consisting of an optical fiber and a metallic cable
	O/E	Optical-to-Electric conversion
20	PCM	Pulse Code Modulation
	QAM	Quadrature Amplitude Modulation
25	IP	Internet Protocol
	RDSLAM	Remote DSLAM of an FTTC network
	VDSL	Very high speed Digital Subscriber Line
30		

Basic idea of the invention

The basic idea of the method in accordance with the invention is that the transmitted and received bit streams transported over each pair cable are transmitted and received over the optical fiber by the RDSLAM using a multiplexing method based on the multiplexing of optical signals. Hence the multiplexing requires no common multiplexing electronics and the operation of the optical-to-electric and electric-to-optical conversion electronics of each subscriber is not dependent on the condition of the conversion electronics of other subscribers. This makes it possible to feed the operating power for the optical-to-electric and electric-to-optical conversion electronics of each subscriber, which is located in the RDSLAM, through the pair cable of each subscriber. In an RDSLAM based on prior-art technology, the multiplexing equipment common to all DSL modems requires such high power that it is not possible to feed all the power through the pair cable of only one subscriber. But it is necessary that the equipment functions even when only one subscriber connection is active at a time.

FIG. 2 depicts essential details of the method according to the invention. An optical fiber 2 is connected between the conversion and multiplexing equipment 100 at the central site and the RDSLAM equipment 103 which is closer to the subscribers. A metallic pair cable 4 connects the DSL modem 5 of each subscriber to the RDSLAM. Data is transported in both directions over a pair cable 4 by using a modulation method appropriate for a subscriber cable, for example, a DMT or QAM method referred to in VDSL standard drafts. A conversion element 105 converts an electric signal received from the pair cable into optical form. Furthermore, the conversion element 105 converts an optical signal, received from the optical fiber and intended for a specific subscriber, into an electric signal to be transmitted over the pair cable. A conversion element 102, located in the central site equipment, carries out a corresponding conversion at the central site. In the electric-to-optical conversion, the signal is also converted into digital form so that the signal is transported over the optical fiber in digital form. In some embodiments, the signal is transported over the optical fiber in analog form instead of digital form. An optical multiplexer/demultiplexer 101, located in the central site equipment, and a

corresponding optical multiplexer/demultiplexer **104**, located in the RDSLAM, multiplex the optical signals of different subscribers onto the optical fiber, so that the signal of each subscriber can be demultiplexed and separated at the far end of the fiber. Because the multiplexing of signals respective to different subscribers is performed by the processing optical signals, there are no common electronics for all subscribers, and the operation of each subscriber's electronics is completely independent of the functioning of other subscribers' electronics. Hence the electronics of each subscriber are also completely electrically independent of other subscribers' electronics, so that the operating power for each subscriber's electronics, which are located in the RDSLAM, can be fed through each subscriber's pair cable from the subscriber's modem **5**. The details for the implementation of the system can vary. Some preferred embodiments are examined in the following.

A preferred embodiment

In a method according to the invention and presented in FIG. **3**, the equipment needed at the subscriber end of the optical fiber, located for example in a street corner cabinet, comprises the essential electronics of the DSL modems **9** (TRCV) including a digital transmitter and receiver **14** (DSP), analog parts, as well as other parts. The essential elements of the analog parts are a digital-to-analog converter **12** (DAC), a transmitter analog filter **10**, a line driver **11**, a hybrid **13**, a receiver analog filter **18**, a controllable level-adjusting amplifier **17** (AGC), and an analog-to-digital converter **16** (ADC). Said elements and their operation are well known to an expert in the field, so it is not necessary to give a more detailed description of them.

A data switch **20** (FIG. **6**) contained by the central site equipment multiplexes bit streams **8a** intended for different subscribers over optical fiber **2** by means of a conversion element **21** (FIG. **6**). The optical bit stream transmitted from the central site over the optical fiber is first distributed to a conversion element **7** (O/E) of each subscriber by means of an optical hybrid **6**. The conversion element **7** converts the optical signal into electrical form and picks up a bit stream **8** intended for each subscriber. The bit stream **8** is fed to a transmitter of a DSL modem **9**, which converts the stream into a signal appropriate for transmitting over the metallic pair

cable to the receiver of a subscriber modem 5. The following procedure is carried out in the other transmission direction. A signal transmitted by the subscriber's modem 5 over the metallic pair cable is processed and detected by the receiver of the DSL modem 9. A detected bit stream 19 originating from a subscriber is converted into optical form by a conversion element 7, using a multiplexing method whereby bit streams originating from different subscribers can be separated by a respective conversion element 21 at the central site (FIG. 6). The bit streams 19a received from different subscribers are fed into a data switch 20, which processes the data streams according to the applied protocol, e.g. Ethernet protocol.

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Signal multiplexing is carried out by multiplexing and demultiplexing optical signals according to the method illustrated in FIG. 3 whereby the conversion element of each subscriber is completely electrically independent from all other conversion elements in the RDSLAM. Hence the operating power can be fed to each subscriber's modem and conversion element from the subscriber end of the cable. This is carried out by feeding a DC current from a current supply element of a modem 5 to the cable and by conveying the current through a hybrid 13 to a power converter element 15, which generates the operating power for the device. Remote power feeding over a subscriber cable is prior-art technology and has long been used, for example, in PCM repeaters, and the details of implementation are not essential for the operation of the present method.

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Second preferred embodiment

FIG. 4 depicts the second preferred embodiment of the method in accordance with the invention. The embodiment is very similar to the previous embodiment of FIG. 3, with the difference that the RDSLAM equipment contains only the analog parts 26 of the modems, the digital transceivers 9 of the modems (FIG. 7) being located at the central site. Optical fiber 2 transports a digital sample sequence 23 from the transmitter of the transceiver to the DA converter, and said optical fiber also transports a digital sample sequence 24 from the AD converter to the receiver of the transceiver, the AD and DA converters being located in the RDSLAM and the transmitter and receiver being located at the central site. The signal transported over

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the optical fiber is distributed to each subscriber by an optical hybrid 6. A conversion element 7 demultiplexes from said signal a sample sequence intended for the DA converter of each subscriber. Furthermore, the conversion element 7 converts into optical signals sample sequences 24 produced by each subscriber's AD converter and multiplexes them to the optical fiber by means of the optical hybrid 6.

FIG. 7 illustrates equipment at the central site corresponding to the RDSLAM of FIG. 4. An optical hybrid 22 and a conversion element 21 perform tasks similar to the optical hybrid 6 and conversion element 7 of the RDSLAM in FIG. 4. The optical fiber transports digital sample sequences 23a and 24a between the DA and AD converters and the digital transceivers 9. The transceivers are connected to a data switch 20, for example, to an Ethernet switch.

Signal multiplexing is carried out by multiplexing and demultiplexing optical signals in accordance with the method according in FIG. 4. Therefore, the electronics of each subscriber and their functioning in the RDSLAM are independent of the state of other subscriber's electronics. Hence the operating power for said electronics can be fed from the subscriber end of a cable, i.e. DC current is fed to the cable from a current supply element of the subscriber's modem 5. The DC current that is flown through the cable is conveyed by a hybrid 13 to a power converter element 15, which generates the operating power for the device.

Third preferred embodiment

FIG. 5 depicts the third preferred embodiment of the method in accordance with the invention. In this embodiment, the RDSLAM equipment comprises only modem analog parts 27, excluding the AD and DA converters. The AD and DA converters 12 and 16 are now located at the central site according to FIG. 8 and connected directly to digital transceivers 9. An optical fiber 2 transports an analog signal 28a produced by the DA converter, whereby the signal is multiplexed in the fiber optically in analog form in such a way that the received signals 28 (FIG. 5) can be separated from each other by the RDSLAM equipment. Respectively, the analog signals 29 produced by each subscriber's analog parts and intended for the AD

converters are transported over the optical fiber multiplexed optically in such a way that each subscriber's signal **29a** (FIG. 8) can be separated from the others' at the central site. The multiplexing, demultiplexing, and conversion from and into electrical and optical forms of the above-mentioned signals are carried out by means of an optical hybrid **6** and a conversion element **30** in the RDSLAM (FIG. 5) and by means of an optical hybrid **22** and a conversion element **31** at the central site (FIG. 8). The digital transceivers **9** in FIG. 8 at the central site are connected to a data switch **20**. Accordingly, analog signals are multiplexed over the optical fiber in this embodiment, whereas digital signals are multiplexed in the first two embodiments. Consequently, in this embodiment different characteristics are required for signal multiplexing than those required in the first two embodiments.

Multiplexing of optical signals

It is possible to implement the multiplexing of optical signals by means of several different methods. Which is the most favorable multiplexing method greatly depends on the available technology, especially on the status of the optical component technology. However, the multiplexing method utilized is not essential for the technical functioning of the method according to the invention. Next to be depicted are certain methods feasible with state-of-the-art technology for multiplexing optical signals. There is great variation in such methods when comparison is based on the implementation costs resulting from available technology. However, the advancement of technology, especially laser technology, may change the situation in the future.

Optical multiplexing method 1

The signals of different subscribers are separated from each other by applying the wavelength multiplexing of optical signals. The signal of each subscriber is transported over the optical fiber by using a different wavelength for the signal of each subscriber, so that the signals of different subscribers can then be separated from each other with appropriate filters in the receiver.

Optical multiplexing method 2

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The signals of different subscribers are separated from each other by applying the frequency division modulation of a laser beam. This method is also a kind of wavelength multiplexing, but now the signals of different subscribers are at a distance ranging from a few MHz to about 10 – 30 MHz in the frequency domain.

- 10 The modulation is implemented in the first phase by modulating the signal of each subscriber so that the subscribers' signals are located at the above-mentioned distance from each other in the frequency domain. Thereafter, a laser transmitter is modulated with the signal produced in the first phase. The signal processing within the system may be implemented partly with the aid of digital signal processing and
- 15 partly by means of analog circuitry.

- In so far as this method is applied for transporting signals from the RDSLAM to the central site, the frequencies of each subscriber's transmitter have to be mutually interlocked. Interlocking can be implemented, for example, by synchronizing the
- 20 lasers' frequencies with a pilot signal contained in the optical signal received from the central site.

Optical multiplexing method 3

- 25 The signals of different subscribers are multiplexed on the optical fiber by using time division multiplexing. A subscriber-specific time window is at each subscriber's disposal by turns, so that only one subscriber's signal is transferred on the fiber within that time window.

30 *Optical multiplexing method 4*

The signals of different subscribers are multiplexed on the optical fiber by using code division multiplexing. The signal of each subscriber is transferred at the same optical

signal wavelength so that each subscriber's signal is separated from the others' by using a different code sequence for each subscriber.

5 Because the third preferred embodiment of the method in accordance with the invention is based on the optical multiplexing of analog signals, all multiplexing methods described above are not suitable for implementing the third embodiment. The optical multiplexing methods 1 and 2 illustrated above can be applied for multiplexing analog signals with present technology.

10 Although the above description of the invention refers to the examples in the accompanying drawings, it is apparent to an expert in the field that the invention is not limited by the examples but that various modifications are possible within the scope of the invention claimed. For example, (a) the fiber link may comprise several full-duplex fibers or there may be separate fibers for the two transmission directions,
15 (b) the multiplexing methods depicted above can be applied in various combinations and (c) other multiplexing methods than depicted above can be used. For example, it is possible to use a combination of time division and frequency division multiplexing methods.

References

[1] US patent 5,526,154, *Method of establishing a subscriber connection and a*
5 *subscriber network.*

[2] WO03017634, *Method of establishing a subscriber connection and system*
utilising the method.

Claims:

1. A method for establishing a digital hybrid subscriber connection
- 5 consisting of an optical fiber and a subscriber-specific metallic pair cable, whereby
- (a) a subscriber connection comprises an optical fiber (2), a metallic pair cable (4),
- and equipment (103) adapting said optical fiber and cable to each other so that the
- optical fiber goes towards a central site and the pair cable goes towards a subscriber,
- (b) a subscriber's transmission device (5) is connected to the metallic pair cable of
- 10 the respective subscriber at the subscriber end of the pair cable, (c) a subscriber-
- specific first analog or digital information stream, intended for each subscriber, is
- transported over the optical fiber (2), and (d) a second information stream, produced
- by each subscriber, is transported in analog or digital form over the optical fiber (2)
- from said equipment (103) to the central site,
- 15 the method comprising the steps of adapting said equipment (103)
- for converting the first optical analog or digital information stream of
- each subscriber, transported over the optical fiber and intended for the respective
- subscriber, into electrical form and transmitting said first analog electric signal over
- the pair cable (4) to the subscriber's transmission device (5) and
- 20 - for converting a subscriber-specific second analog electric signal,
- transmitted by each subscriber's transmission device (5) over said pair cable (4), into
- an analog or digital optical signal and feeding this second information stream further
- over the optical fiber to the central site, and
- further comprising the step
- 25 - of multiplexing the first and second digital or analog optical
- information stream of several subscribers into one or more optical fibers (2) in both
- transmission directions,
- characterized** by
- inserting subscriber-specific conversion elements (105) into said
- 30 equipment (103), said elements to comprise active electronics which are adapted to
- separate each subscriber-specific optical analog or digital first information stream
- from other subscribers' first information streams and to convert said first information
- stream into an analog electric first signal, and further to feed said first signal over the

respective pair cable (4) to the subscriber's transmission device (5), and adapted to convert each subscriber-specific analog second signal transmitted by the subscriber's transmission device (5) over the respective pair cable (4) into an optical analog or digital second information stream,

5 - multiplexing the first information streams at the central site onto the optical fiber (2) by utilizing such multiplexing method so that (i) said subscriber-specific first information streams can be distributed to each subscriber's conversion element (105) by means of passive optical elements, and so that (ii) said transmission element (105) of each subscriber is able to separate the first information stream,
10 intended for the respective subscriber, from other subscribers' first information streams,

 - adapting said equipment (103) to distribute the optical analog or digital first information streams to the conversion element (105) of each subscriber by means of passive optical elements,

15 - adapting said equipment (103) to combine the optical analog or digital second information streams of all subscribers and to feed the combined second information streams into the optical fiber (2) by means of passive optical elements,

 - adapting said conversion elements (105) to operate independently so that each conversion element (105) is capable of operating without being dependent
20 on the state of operation of other subscribers' conversion elements, and

 - feeding the operating electric power through the pair cable (4) of each subscriber to the user-specific conversion elements contained in said equipment (103).

25 2. A method according to claim 1, **characterized** by

 - adapting each subscriber's transmission equipment (5) to feed direct electric current into the metallic pair cable of respective subscriber and

 - inserting a power-generating element (15) into the subscriber-specific conversion element (105) and adapting said power-generating element (15) to
30 produce the operating electric power for the conversion element (105) from the direct electric current which is fed through the pair cable (4).

3. A system for establishing a digital subscriber connection, consisting of a composition of an optical fiber and a metallic pair cable, in which system (a) a subscriber connection comprises an optical fiber (2), a metallic pair cable (4), and equipment (103) adapting said fiber and pair cable to each other so that the optical
5 fiber goes towards a central site and the pair cable goes towards a subscriber, (b) in which system a subscriber's transmission device (5) is connected to the metallic pair cable (4) of each subscriber, (c) the system comprising first transmission elements for transporting a first information stream, intended for each subscriber, over the optical fiber (2) in analog or digital form from the central site to said equipment
10 (103), and (d) the system comprising second transmission elements for transporting a second information stream, produced by each subscriber, in analog or digital form over the optical fiber (2) from said equipment (103) to the central site, and

- means for converting the analog or digital first information stream, intended for the subscriber, into electric analog form, and for feeding this analog first
15 signal to the subscriber's transmission device (5) over the pair cable (4), and also

- means for converting a second electric analog signal, which is transmitted by the subscriber's transmission device (5) and transported over the pair cable (4), into an optical signal in analog or digital form, and for transmitting this second information stream over the optical fiber to the central site, and

20 - means for multiplexing the first and second analog or digital information streams of several subscriber connections onto one or more optical fibers (2) in both transmission directions,

characterized in that

- said equipment (103) consists of subscriber-specific conversion
25 elements (105) comprising active electronics, which separate each subscriber-specific optical analog or digital first information stream from other subscribers' first information streams, convert said first information stream into an analog electric first signal, further transmit said first signal over the respective pair cable (4) to the subscriber's transmission device (5), and convert each subscriber-specific analog
30 second signal transmitted by the subscriber's transmission device (5) over the respective pair cable (4) into an optical analog or digital second information stream,

- the system comprises means for multiplexing the first information streams at the central site onto the optical fiber (2) by utilizing a multiplexing

method whereby (i) said subscriber-specific first information streams can be distributed to each subscriber's conversion element (105) by means of passive optical elements and (ii) said transmission element (105) of each subscriber is able to separate the first information stream, intended for the respective subscriber, from other subscribers' first information streams,

- said equipment (103) comprises means for distributing the optical analog or digital first information streams to the conversion element (105) of each subscriber by means of passive optical elements,

- said equipment (103) comprises means for combining the optical analog or digital second information streams of all subscribers and feeding the combined second information streams into the optical fiber (2) by means of passive optical elements,

- said conversion elements (105) operate independently so that each conversion element (105) is capable of operating without being dependent on the state of operation of other subscribers' conversion elements, and

- the operating electric power is fed through the pair cable (4) of each subscriber for the user-specific conversion elements contained in said equipment (103).

4. A method according to claim 3, characterized in that

- each subscriber's transmission equipment (5) comprises means for feeding direct electric current into the metallic pair cable (4) of said subscriber, and

- a user specific conversion element (105), included in said equipment (103), contains a power-generating element (15) for producing the operating electric power for the conversion element (105) from the direct electric current, which is fed through the pair cable (4).

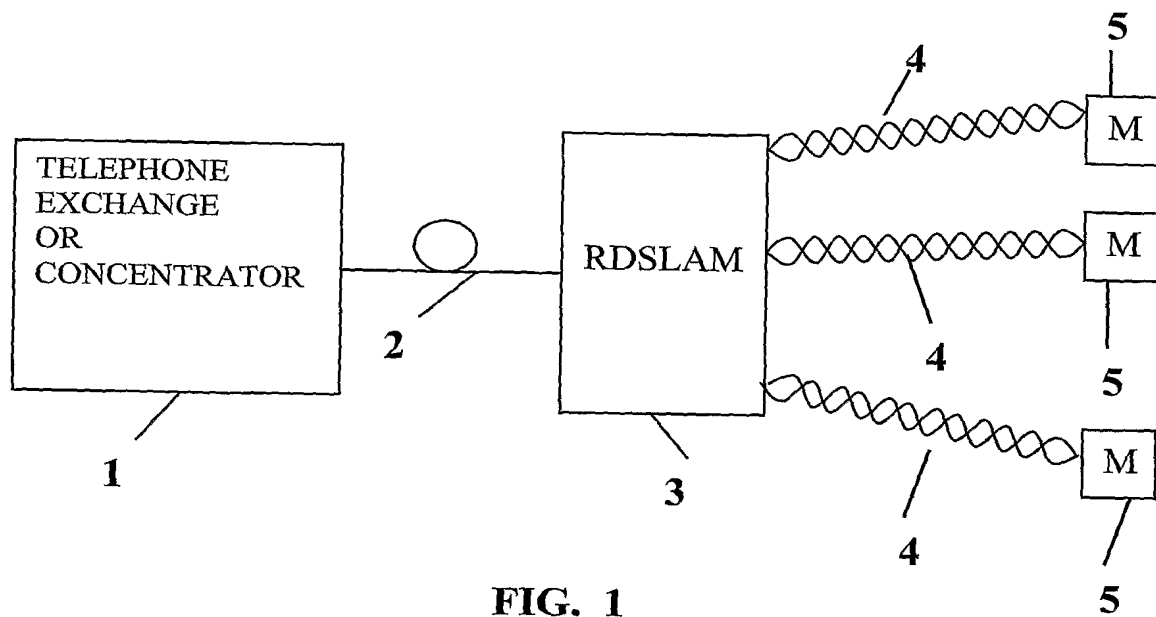


FIG. 1

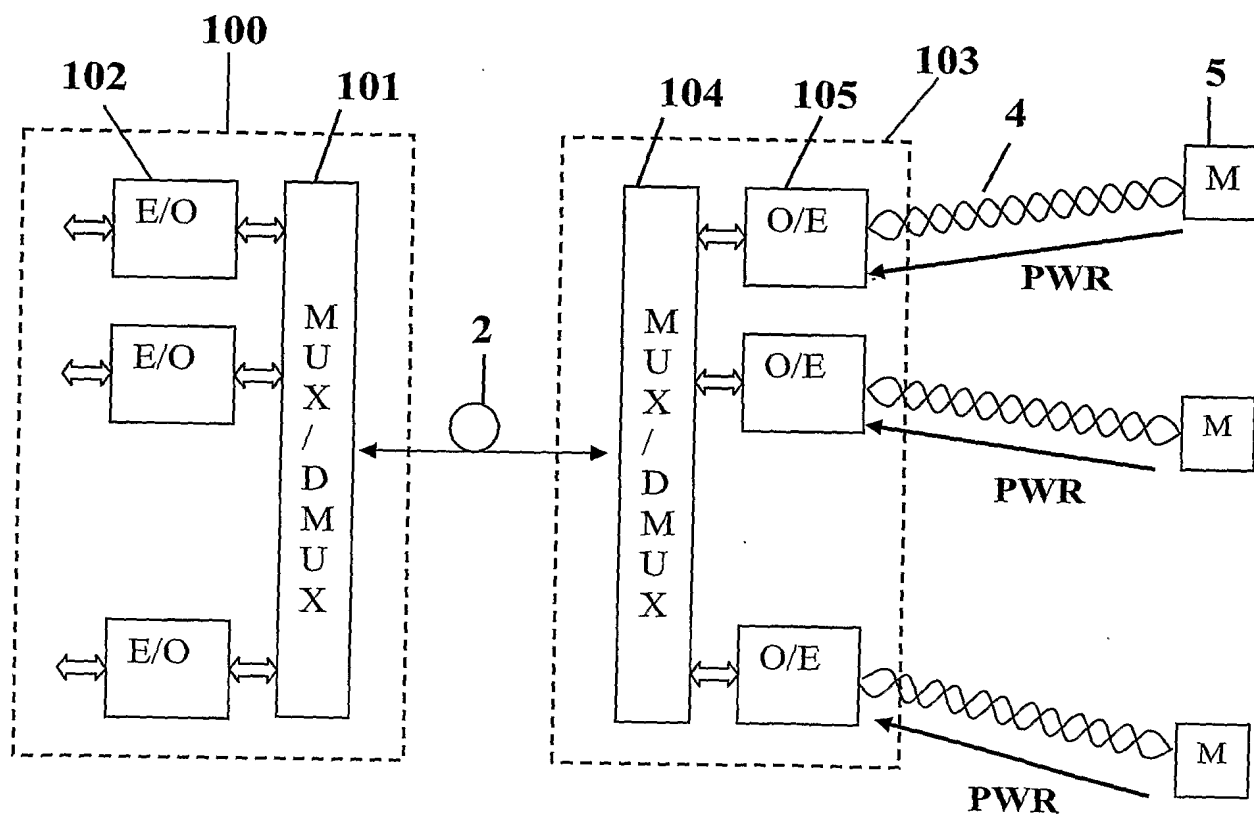


FIG. 2

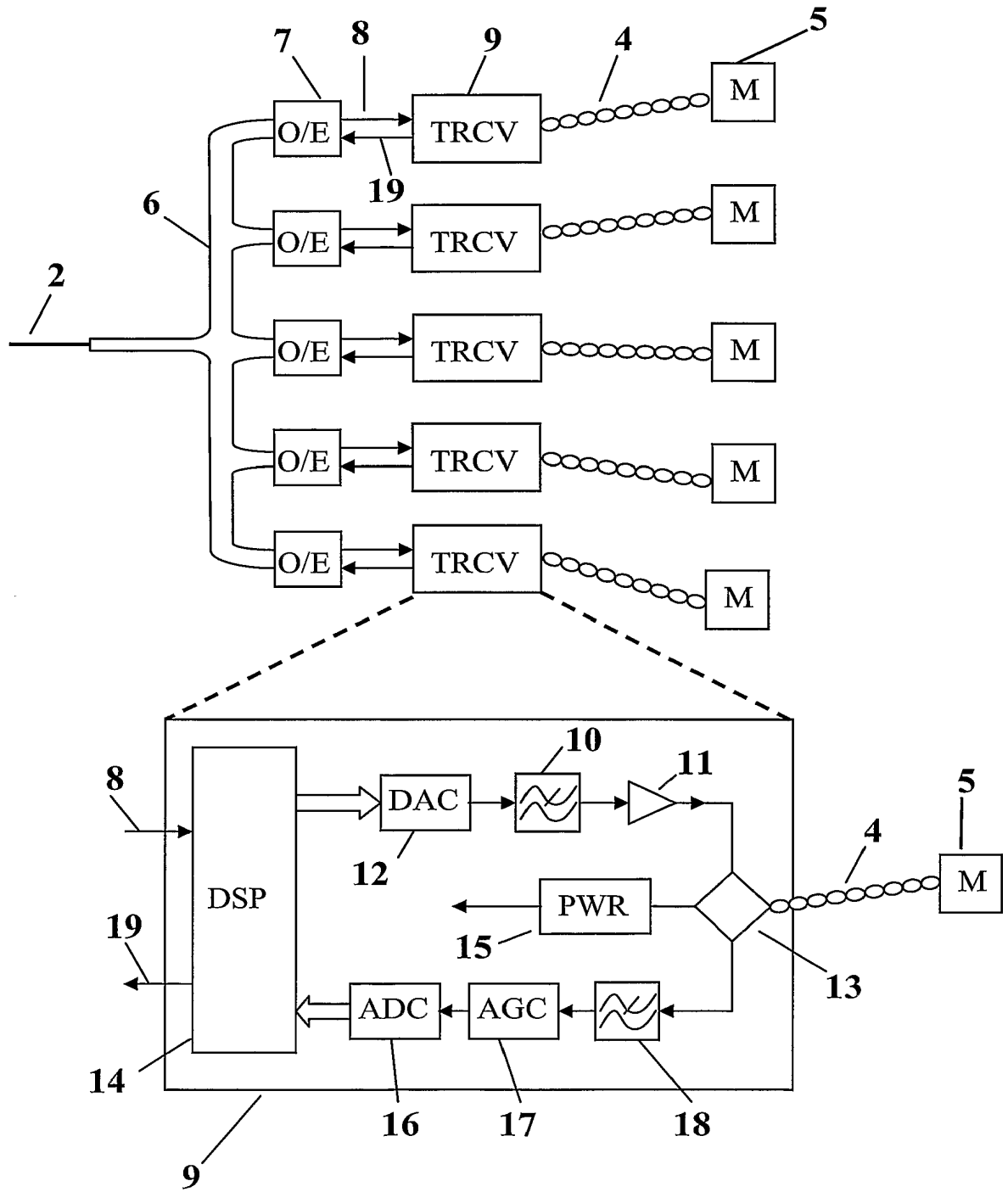


FIG. 3

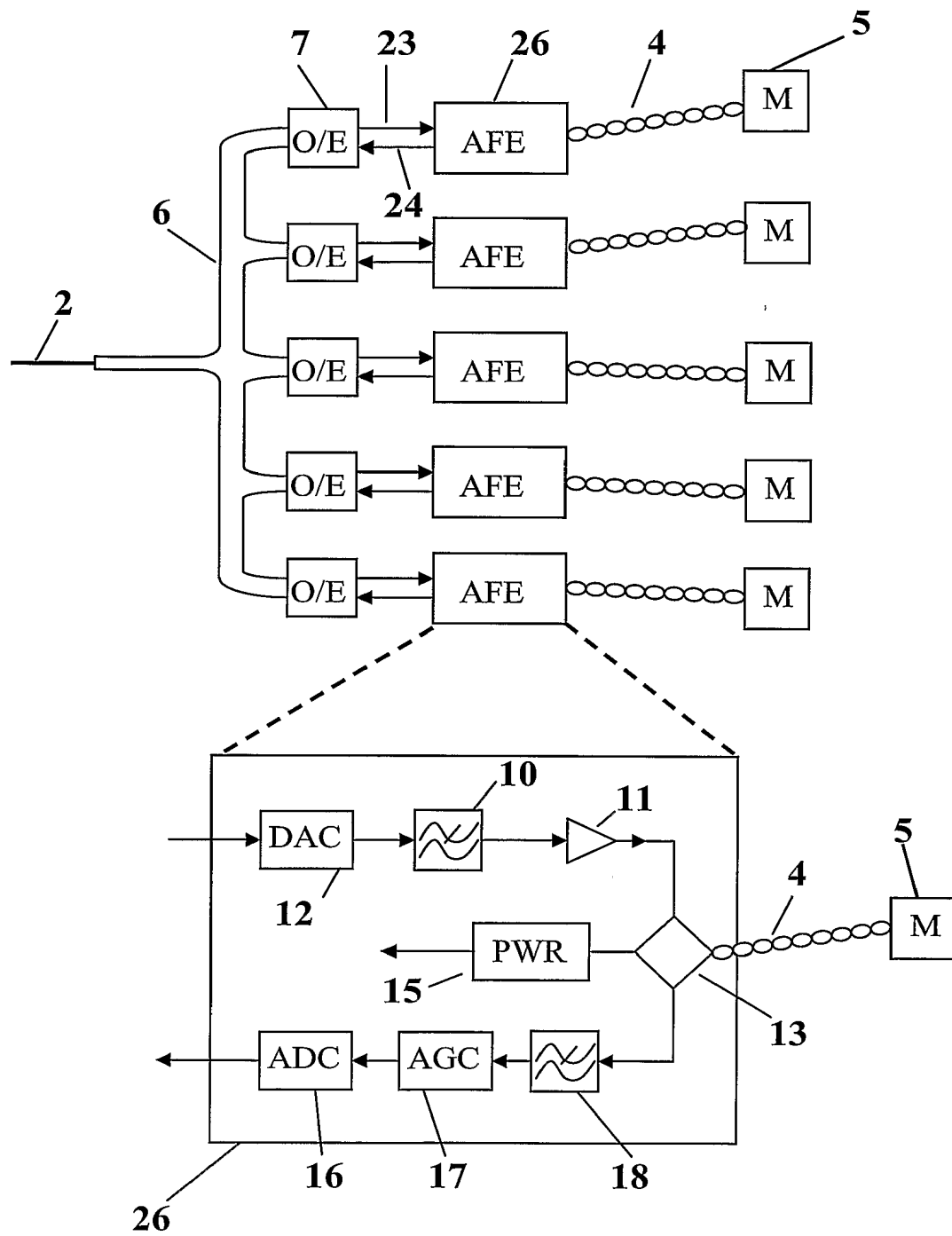


FIG. 4

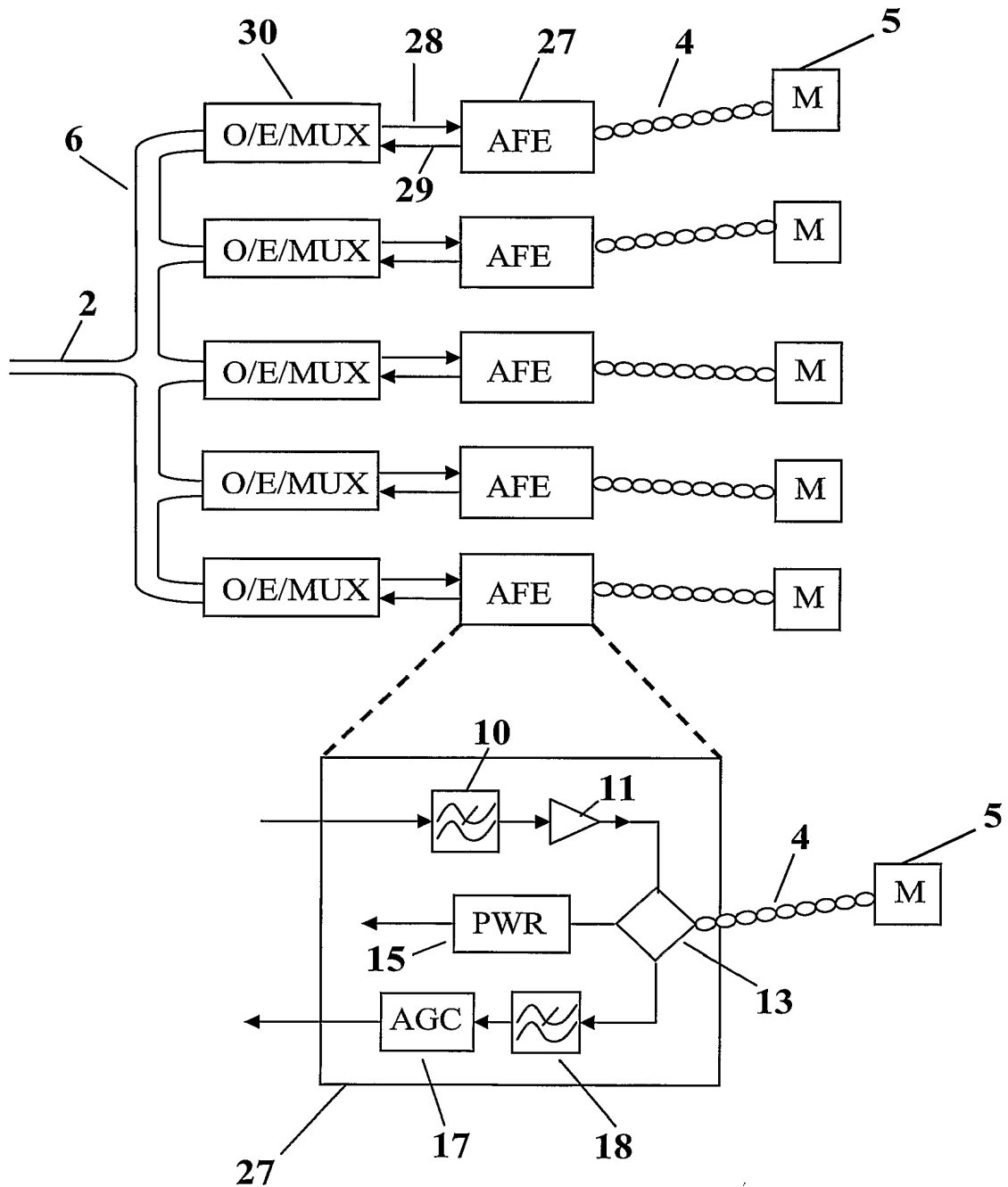
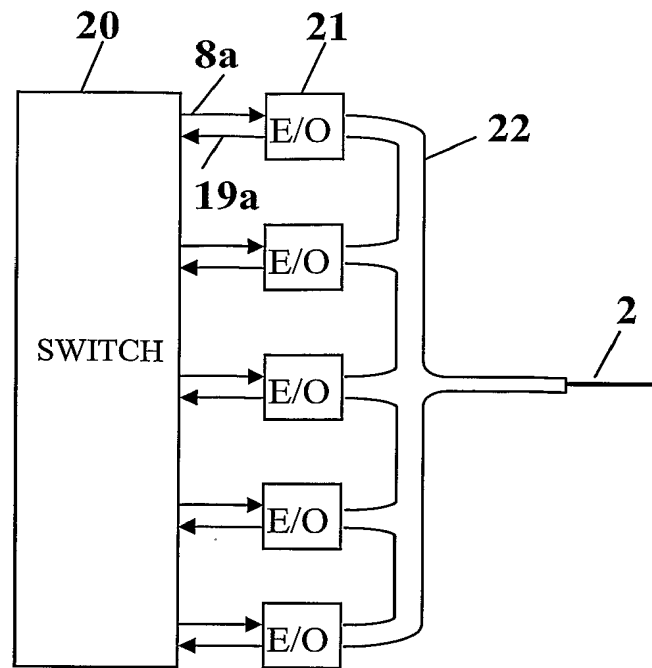
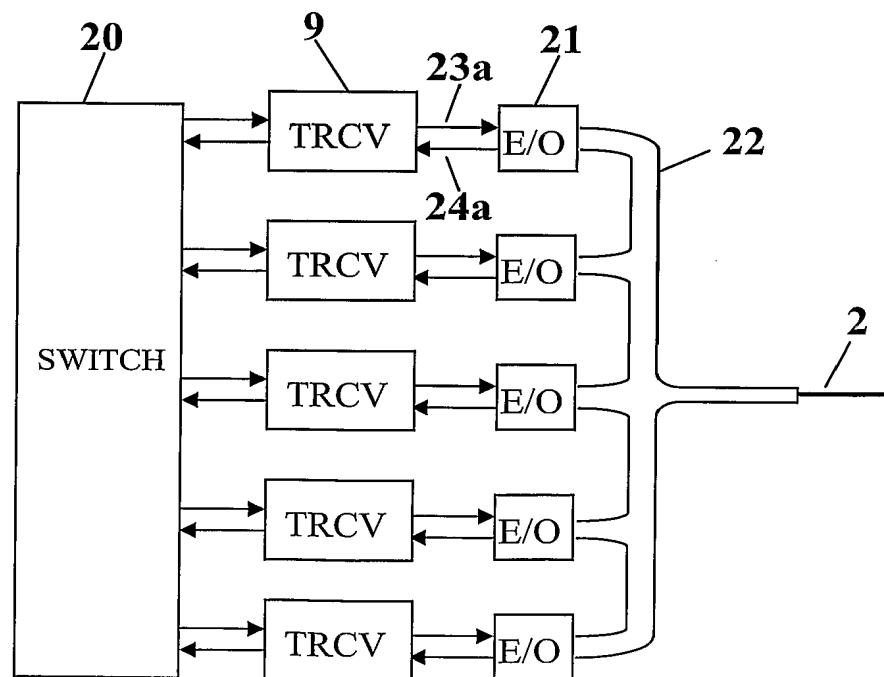
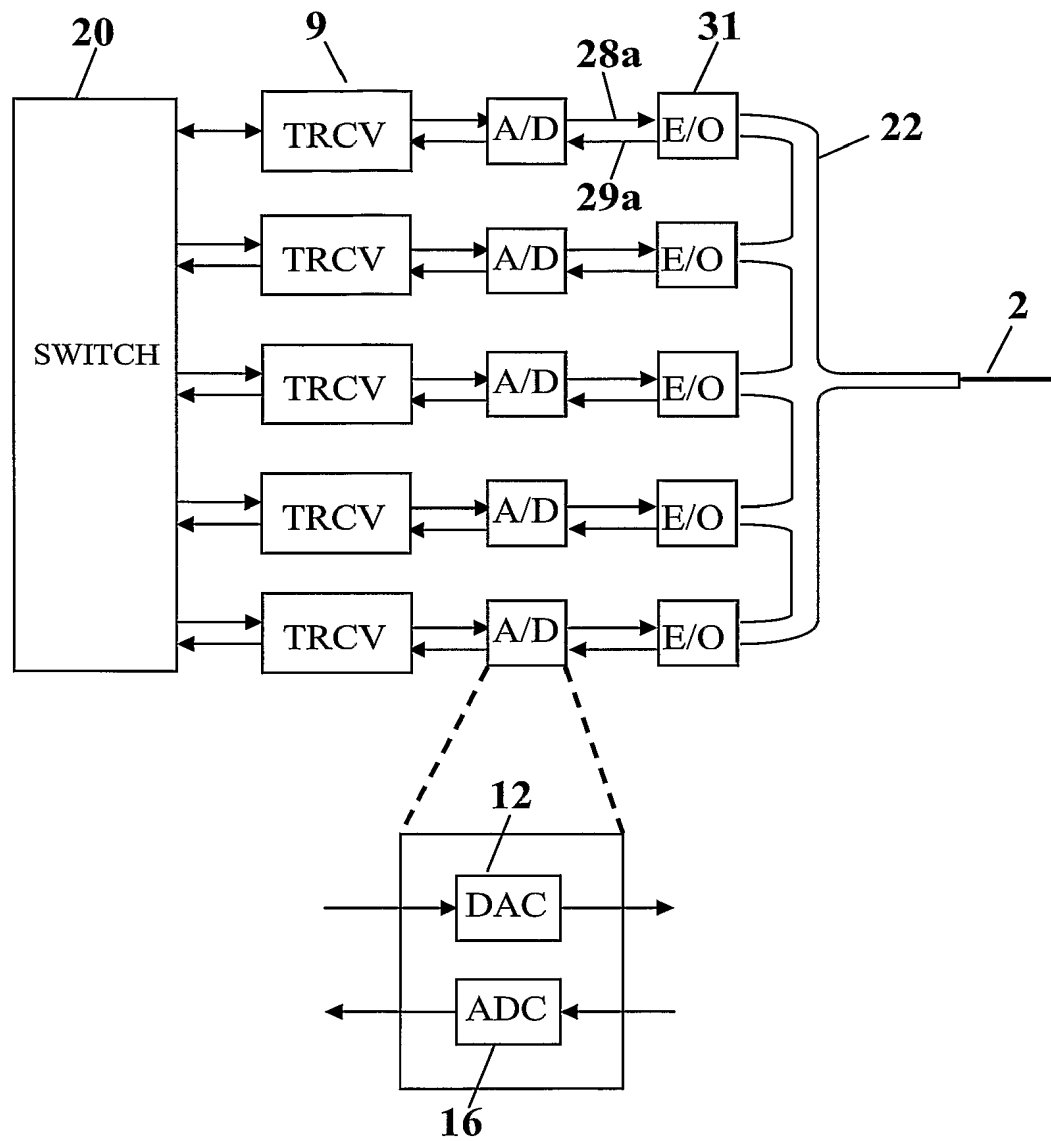


FIG. 5

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**FIG. 6****FIG. 7**

**FIG. 8**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 2004/000612

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 10/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL,WPI,PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1009156 A2 (TADIRAN TELECOMMUNICATIONS LTD. PETAH-TIKVA 49104 (IL)), 14 June 2000 (14.06.2000), column 1, line 44 - line 47, part(0012) --	1-4
X	DATABASE WPI Derwent Publications Ltd., London, GB Class W01 W02, AN1999-088233 & JP10322460 A (MATSUSHITA ELECTRIC IND CO LTD) 4 December 1998 (1998-12-04) abstract --	1-4
X	US 6577882 B1 (STURE ROOS), 10 June 2003 (10.06.2003), column 2, line 18 - line 22 --	1-4

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

2 March 2005

Date of mailing of the international search report

03-03-2005

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 2004/000612

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4525834 A (K.D.SCHENKEL ET AL), 25 June 1985 (25.06.1985), column 2, line 45 - column 3, line 6, figure 1 --	1-4
X	DE 4217297 A1 (SIEMENS AG), 2 December 1993 (02.12.1993), abstract -- -----	1-4

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/FI 2004/000612

EP	1009156	A2	14/06/2000	NONE		
<hr/>						
US	6577882	B1	10/06/2003	AU	7820300 A	24/04/2001
				BR	0014245 A	21/05/2002
				CN	1376358 T	23/10/2002
				EP	1216572 A	26/06/2002
				SE	9903476 A	25/03/2001
				WO	0122716 A	29/03/2001
<hr/>						
US	4525834	A	25/06/1985	AT	17905 T	15/02/1986
				CA	1160771 A	17/01/1984
				DE	3045876 A	08/07/1982
				DE	3173727 D	00/00/0000
				EP	0053674 A,B	16/06/1982
				SE	0053674 T3	
				JP	1631637 C	26/12/1991
				JP	2059658 B	13/12/1990
				JP	57121342 A	28/07/1982
<hr/>						
DE	4217297	A1	02/12/1993	NONE		
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